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GARBAGE COMPOSTS AND RELATED DISPOSAL METHODS

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Garbage disposal is a large item of expense in most of the cities of the United States. About 50 percent of the people of this country live in cities of 10,000 or more inhabitants. This means that the garbage from about 75 million of our people is not easily returned to farms where it might be most useful.

In Washington, D. C., a city of about 800,000 population, annual garbage production from homes, hotels, restaurants, and food stores is about 88,000 tons. If annual production at this rate be projected for about 75 million people of the United States living in cities, an approximation of about 8 million tons of garbage annually is indicated.

A great deal of consideration has been given to the possibility of lessening the expense of garbage disposal through salvage in the form of certain products. It is the purpose here to consider some of the methods currently used, and some of the procedures that have been used and later abandoned, and to consider certain future possibilities.

The look into the future involves primarily a consideration of the economic prospects for garbage composts. But, the consideration must include other means by which disposal costs may be lessened.

Garbage is essentially an agricultural product, directly or indirectly a product of the soil. If it could be economically returned to land it might be a sizable factor in soil conservation of limited areas. Many people of the United States are interested in garbage from the standpoint of the economics of its disposal. Others are interested in its possible use for soil improvement. The Department of Agriculture is concerned with an over-all view of the subject looking toward the rightful place of garbage in agriculture insofar as it has such a place. While the Department is interested in the possible salvage of some garbage through composting it is not thought that such organic ammoniates will become an important or highly competitive factor in the field of fertilizer nitrogen. Garbage also contains small amounts of other essential plant nutrients that are badly needed in certain soils.

Chemical composition of garbage

The chemical composition of essentially organic garbage varies widely from city to city; also, from time to time and from place to place within a particular city. Analytical data taken partly from the files of this Station and covering a number of years may be used as a first approximation of the chemical character of material that may be expected in city collections. Data are given in Table 1.

City garbage, as collected, contains a great deal of water. The quantity present often ranges from about 65 to 75 percent of the total weight. Transportation is usually in water-tight truck bodies to avoid dripping on the

streets. Disposal of the water present involves considerable cost of handling or processing regardless of use made of the material.

Review of Disposal Methods

Can the fertilizer industry compete with the pig in garbage disposal? This important question demands our first attention. Its consideration involves such factors as source of garbage, contamination with solid inorganic materials, frequency of collection, relation between city and country areas, and price of hogs.

In the Washington area, the garbage from public eating places and army camps is of relatively good quality for use as feed. Advent of the hog disease called V.E. has led to a requirement in nearly all States that garbage used for hog feed must be cooked. This adds to cost but increases palatability of the feed in most cases. As a rule costs are not prohibitive when a considerable number of animals are kept on a farm. Water-tight truck bodies fitted with perforated steam pipes such as are often used for cooking are shown in figure 1.

Incineration is a disposal process widely used. This takes care of both trash and garbage. Several cities report costs of handling to range from 4 to 6 dollars per ton. The small city of Hyattsville, Maryland, accepts any kind of trash or garbage for furnace disposal at 5 dollars per ton. A photograph of that plant is shown in figure 2.

The land fill is another widely used system of disposal. This means that waste land must be available within reasonable distance from the city. Poor quality waste material from Washington City is buried at Cherry Hill,Virginia, a distance of some 35 miles on a direct rail route. Equipment in operation is shown in figure 3.

A few years ago so-called garbage tankage was prepared in a number of cities. This was a heat-treated material with most of the fat removed. Some 20 years ago a fairly good market was available for crude fat. The dried tankage material was sold to manufacturers of mixed fertilizers. It served a dual role as conditioner and as low-grade organic ammoniate. The composition was often approximately as shown in Table 2. Under present conditions neither the tankage nor the fat meets a favorable market. Such materials might be used as fuel at the point of disposal but the economic return would probably not be high.

A great deal of city garbage is ground and passed through sewage disposal systems. A number of cities urge home owners to provide garbage grinders in their kitchens. Some cities, including Richmond, Indiana, collect garbage and transport it to the sewage disposal plant where it is ground and fed into a partially activated disposal system. The additional methane derived from the garbage adds several hundred dollars annually to the value of the gas produced in the disposal system.

Garbage, fresh or locally composted, may be used for soil improvement in gardens of suburban areas when sanitary rules permit. An excellent substitute for barnyard manure may be prepared in a compost heap, as shown in figure 4. Whenever the soil is unfrozen and a suitable area is available, the equivalent of compost may be made in the soil. The garbage is completely covered with earth. Decomposition in the soil is rapid during warm weather. In winter time rats may be attracted by partially decomposed garbage within their reach.

When composting is expanded from a back yard job to a commercial process, economic difficulties are involved. This phase of the subject now demands particular attention.

Changes During Composting

Under normal conditions of composting where adequate aeration is provided, a series of changes may be expected:

1. Carbohydrates, fats, proteins, and to some extent lignin, undergo decomposition. Non-nitrogenous materials such as carbohydrates, through their decomposition furnish energy for building the tissues of living organisms. These organisms die, leaving bodies of much higher nitrogen content than prevailed in the mixture.

2. The bacteria, fungi, and other bodies formed may decompose more slowly in the soil than do fresh plant materials.

3. The prevailing groups of organisms present in a compost change rapidly. During early stages a very active flora is present. The temperature may then rise, destroying many organisms in groups previously active. Thermophylic organisms then take over to play a leading role, carrying temperatures up to perhaps 150° to 160°F., provided moisture conditions are suitable. Rate of organic decomposition at the higher temperatures may be retarded under certain conditions, but data on this point are not satisfactory.

4. Partial sterilization takes place at the higher temperatures reached. This tends to destroy weed seeds if present and to improve sanitation within the material.

5. An increase in mineral content is inevitable as organic materials of a compost lose cellulose and certain other organic compounds by decomposition.

6. Sufficient change in the character of the organic material takes place so that it no longer gives off an offensive odor during a prolonged damp period. It is often said to be stabilized.

Very little information is available regarding the chemical composition of garbage composts. Still less is known about the rates of nitrification of such materials in soil and about their general value as fertilizers

or for improvement of the physical condition of soil. The compositions of such materials vary with the quality of garbage used; the amount of earth added, if any; chemical supplements incorporated; the extent of decomposition, and possible losses through volatilization of ammonia or by other losses through drainage water.

Garbage composts have been made in this country in small quantities by various processes. The limited records available vary in type of information provided. The data given in Table 3 are probably representative of products that have been developed. Beyond this information is a field for much speculation based upon fragmentary data.

Some of the topics for profitable speculation and subsequent experimentation include these:

1. How high can the nitrogen content of a compost be developed without serious loss of nitrogen during decomposition?

2. Do serious nitrogen losses take place when a compost is dried? If so, what is the relation of nitrogen content to nitrogen loss.

3. What are the relative contents of decomposed plant materials present and of bodies of organisms in a fully developed compost?

Table 3 shows no nitrogen content of garbage compost as high as 3 percent. Probably it is impractical to develop composts with nitrogen contents higher than about 3 percent. Some of the factors involved are these.

1. When plant material of nitrogen content higher than about 1.5 percent is allowed to decompose, free ammonia is developed. Some of this may, however, be absorbed by the plant tissues and by the moisture present.

2. A small amount of soil is often added as an inoculant. Inorganic residues also accumulate as organic decomposition takes place. These materials have some absorbing power for ammonia.

3. As ammonia accumulates the mass becomes more alkaline in reaction and less able to hold additional amounts of ammonia.

4. Increased temperature and the process of drying hastens loss of ammonia present in free or sorbed form.

Taking into account various factors involved in garbage compost formation, it may be interesting to speculate regarding the character of a fairly well stabilized product. It may be assumed that this is developed through a period of about 3 weeks incubation during which time conditions probably included fairly good aeration, an adequate supply of moisture, and temperatures not in excess of 120°F. During this period one-half of the dry weight may be assumed to be lost.

Certain characteristics of this hypothetical product are summarized below:

Constituent	Amount present	Nitrogen Content of Constituent	Contribution to N Content of Whole of Product
	percent	percent	percent
Stabilized humus	40	2.8	1.12
Partly decomposed plant material	25	1.4	.35
Bacterial bodies	10	8.0	.80
Fungus and other bodies	10	5.0	.50
Earthy material	15	0	-
			2.77

The composted product varies from the original mass in a number of ways. It may be assumed that before composting, the garbage on a dry basis consists of about 93 percent undecomposed plant and animal matter and 7 percent earthy material and no humus.

Inoculation

Micro-organisms of many kinds are indigenous to municipal garbage in great numbers. Recent studies at the University of California have shown that inoculation with specially prepared organisms is entirely superfluous. Furthermore, changes in dominance of classes of organisms during composting may be expected. The addition of a little garden soil and well rotted manure at the beginning of a composting period should supply any inoculation that might possibly be desirable.

On may assume that a dry compost can be formed that has suitable physical condition and a nitrogen content somewhere between 2.0 and 3.0 percent. If nitrates were present in substantial quantity the nitrogen content might run a little higher without serious loss of this constituent on drying. The moist conditions of compost formation do not, however, favor rapid nitrate formation and accumulation.

Procedures for Commercial Composting

Several processes are presently available for making composts from a wide variety of organic materials.

The Indore process was developed in India more than 50 years ago. It is essentially anaerobic and rather inefficient. The Beccari method introduces more air. It has been used to a limited extent in the United States. The Verdier process is a further modification

of earlier processes and is thought by some to be an improvement over those used earlier. The name Earp-Thomas is also associated with one of the composting processes. The Michigan State College work deserves particular attention. Professor John R. Snell of that institution, working in the Department of Civil Engineering, is investigating problems arising in his field of technology.

It would not be too difficult to select a process or adapt one to local conditions if the mechanics of composting were the only problems to be considered. Attention must also be given to the part of town or nearby country-side where the work is to be done. Some residents object to the presence of a composting plant nearby and to extensive transportation of garbage past their residences.

Any prospective processor wants to know what groups of users might be his customers. Then too, there is the question of competing products often available in local markets.

Prospective Users of Composts

A farmer or technical agriculturist evaluates a fertilizer essentially by what he can read on the bag or tag. In other words he is interested in conventional N, P_2O_5, and K_2O. He realizes that organics may provide added value; how much he does not know; no one knows. More and more farmers are buying their nitrogen in chemical form, relying upon the increased quantities of plant residues and farm manures resulting therefrom to furnish the needed organic matter. This is probably the more economical procedure. Due consideration should be and often is given to the secondary and minor elements present in organics brought to the land.

A farmer will sometimes pay a little money for farm manure near home. Often, however, he expects to get it for the hauling if it is available. Two schools of thought prevail among agriculturists in regard to the value of farm manure. One group says it is worth only the value of its plant nutrients - N, P, K, etc. Another group argues that the added microbiological activity induced in the soil from decaying organics is of great importance, but not clearly defined in value. In fertilizer parlance damp farm manure may be expressed as of about 0.5 - 0.25 - 0.5 grade. The first value represents percent of nitrogen, the second phosphoric oxide, and the third potash. On a dry basis this would be about 1.2 - 0.6 - 1.2. Garbage compost would have a somewhat higher content of plant nutrients than farm manure but not enough higher to place the material in a class attractive to farmers.

The gardener has a different viewpoint from that of the farmer. He is less interested in economics so far as his garden is concerned, but he wants performance. The towngardener with a few hundred square feet of cultivated area usually cannot rotate his land into sod-crops periodically as a farmer would do. Crop residues are often troublesome for the next planting, so low-grade organics such as animal manures, and well decomposed peat are frequently purchased

to supplement commercial fertilizers and to improve the tilth of the soil. Here is one place where garbage composts might find a market, depending on quality and price.

The economics of composts involve consideration of the functions of organics that a user may desire for garden purposes. If the material is to be used, in part, as a mulch on seed beds, partial decomposition of plant remains is frequently desirable. If the compost is to substitute wholly or in part for commercial fertilizers, the contents of available plant nutrients are particularly important. If a garden soil is of heavy texture with a tendency to bake badly, the soil conditioning properties of a compost may be particularly desirable. A slow rate of decomposition would naturally prolong the conditioning effects but would be expected to provide plant nutrients at a slower rate.

The garbage composts listed in Table 3 have properties common to each of the classes outlined. Since very little information is available regarding the properties of garbage composts, it may be assumed that they could be developed in such a manner as to contain a little more nitrogen than commercial animal manures and the rate of decomposition may be slow enough to provide soil conditioning properties over a considerable period. Much of this is speculation; the assembling of facts lies in the future.

Another possible group of purchasers is lawn keepers. Milorganite and seed meals of nitrogen contents ranging from 5 to 7 percent are widely used for the fertilization of lawns and golf courses. Can garbage composts become competitors in this branch of fertilizer practice? Much depends upon the chemical nature of the composts produced. If they are processed in a few days, only long enough to destroy the putrifying odor of garbage materials, chances of successful competition would seem to be poor. If, however, the composting process is carried to a point where the nitrogen content is as high as 3 percent, if indeed this value is practical, there would seem to be a possibility of developing a market among certain people now willing to buy the relatively high-priced organic ammoniates. The home producer of composts often adds a little chemical nitrogen to the heap of organic matter to hasten decomposition and to improve the quality of the product. He also adds a little superphosphate to improve the quality, and a little lime to control development of acidity. If all of these steps are taken in the preparation of commercial garbage composts, there is hope of these materials having a part in the lawn fertilizer trade, provided prices can be made attractive.

Potting Soils

Potting soils used in greenhouses normally contain considerable amounts of organic matter. Farm manures and peat are frequently mixed with soil for this purpose. Garbage composts might work out well for mixing with soil and other ingredients. Greenhouses are frequently located in the metropolitan areas of cities. If garbage composts of the area could be used, the transportation costs might be low enough

to bring composting practice nearer to a commercial basis locally. The market would probably be too limited, however, to absorb the full supply of garbage from a city, provided nearly all of the available material is converted into a commercial compost.

Competitive products

Organic materials differing greatly in origin and in character are prepared for the market and sold to gardeners.

Table 4 lists several organic materials of low nitrogen content available in local stores for use as fertilizers, soil amendments or mulches. The prices given are local Washington quotations for 100-pound lots, delivered to homes. Table 5 gives the price of high-grade organic ammoniates on a similar basis and Table 6 gives local quotations for chemical nitrogen, which prices may be used as a basis for comparison. The data given in Tables 4, 5, and 6 show that nitrogen in organic forms sells locally for at least three times as much as an equivalent amount of this constituent in the cheapest of the inorganic forms. The data show also that blood meal, often regarded as the best source of organic fertilizer nitrogen, sells at a higher premium than does milorganite. The latter, of course, has no feed value.

Animal manures and peat furnish some nitrogen to growing plants but it is evident that purchasers are interested mainly in some other feature of the material. These materials are sometimes used primarily as soil conditioners so that the fertilizer applied with them will be more efficient. Probably also these organics are often used because it is well known that the heavy applications of unprocessed locally produced manures added to farm lands have highly beneficial effects when properly used. The cost of drying and handling freshly dropped manure of dairy barns is a considerable item. One method of drying applicable to other wet organics is shown in figure 5.

Dried animal manures that are relatively free from bedding are frequently sold with a 2 percent nitrogen content guaranteed. The purchaser probably has in mind a small contribution to the humus of the soil as well as a small supply of minor plant nutrients. Some peats are competitors of compost primarily from the soil conditioning standpoint. Nitrogen is present but is usually very slowly available.

Cotton seed meal was once used extensively as a source of fertilizer nitrogen. In 1910, 30 percent of the total tonnage of cotton seed produced was used as fertilizer. By 1950 the percentage of the total production used as fertilizer had dropped to only 2.4 percent. Improved processing made the meal suitable for feed purposes. It is now nearly removed from the fertilizer market, except for specialty uses. This is an illustration of the well known fact that the fertilizer industry cannot successfully compete against animal feed materials. This same principle of thinking can well be carried into our economic consideration in regard to garbage.

Castor pumice and the residues left after extracting oil from tung nuts are non-feed materials and must find relatively cheaper markets as organic ammoniates for soil improvement. They are not readily available in Washington markets, but wholesale quotations for castor pumice on a nitrogen basis is approximately one half of the corresponding price for cotton seed or soybean meal.

Cost of Production and Marketing

Cost of producing garbage compost is difficult to estimate. Furthermore, costs probably vary from place to place. A few estimates have been made. Engineers of the University of California estimate a cost of about 15 dollars per ton for operating a process developed there. Richard P. Stovroff, who has had experience operating a semi-commercial plant at Oakland, California, provides figures as a forecast of a 12-month period of normal operation. He contemplates sale of approximately 62,500 tons of compost for $1,200,000 or about 19 dollars per ton. Professor Snell of Michigan State College has suggested a cost of 5 to 10 dollars per ton for preparing quickly composted garbage.

Any worthwhile evaluation of cost to the gardener must take into account all expenses of retailing, usually including delivery to homes. Since commercial garbage composts are not presently available, a complete picture of economics involved is lacking. It would seem that a prospective producer of garbage composts should consider first the chemistry of his product in relation to price, as summarized in Tables 3 and 4. This provides only a starting point for further economic considerations based on the influence of larger quantities of organics on the market. As indicated before, a general farm market would seem to be economically hopeless. The possible home garden demands are of considerable magnitude but not great compared with possible tonnages available in a metropolitan area. Use by market gardeners is a possibility, particularly if bulk handling and distribution can be successfully worked out. All of this is on the supposition that the product is of a quality comparable to a good farm manure, or better.

Composts in Relation to Local Conditions

The economics of garbage composts may be expected to vary with many factors. Among these are, character of soils of the area, crops grown, and chemistry of compost produced. Composts can well be used in conjunction with commercial fertilizers on soils of heavy texture in home gardens, provided they can successfully compete with cover crops and chemical soil conditioners. The value of improved tilth for plant growth is difficult to estimate, but compost for this purpose should be highly desirable.

Low-grade organics of the type that will probably result from processes under current consideration could also be useful on sandy soils. Water absorption and retention should be improved. The slow liberation of available plant nutrients from decomposing organic matter is likely to be particularly valuable in the more sandy soils.

Kinds of plants grown in an area also affect the economics of proposed garbage compost production. A market gardener may need to improve the tilth of his soil if he is to raise root crops, while such improvement might be less needed if he grows certain other crops. Often a gardener wants to cover rows of freshly planted seeds with a light covering of partially decomposed compost; a garbage product might be suitable.

Influence of Garbage Compost on Quality of Food

Are the food qualities of crops growing in soil fertilized with compost favorably affected? A few words on this oft-discussed subject are included here. So far as is known, the presence of organic matter in a soil as a source of nutrients for growing plants has little or no influence on quality of foods. Good-quality organic matter in soil is desirable from the standpoint of physical character of the medium in which the plants grow. It is not a factor from the standpoint of health-promoting qualities of foods.

Concluding Statements:

1. Good quality garbage is necessary for making good garbage composts. Combustible and non-combustible rubbish lowers the quality of the final product. By far the most significant economic consideration is the potential impact of increased costs on established refuse collection and disposal practices, particularly in American cities where household garbage, even when collected separately, is usually highly contaminated with foreign material such as tin cans, bottles, etc.

2. Good quality garbage collected and brought to a central point is usually more valuable as hog feed than for conversion into compost for soil improvement.

3. Garbage compost properly prepared should be useful in home and market gardens. Its main competitors may be the dried animal manures now available.

4. Particular attention should be given to developing markets in the area where produced. Bulk distribution of the major part of the output may be desirable, thus eliminating the last step of drying and the cost of bagging.

5. Research is needed to determine the rates at which composts of varying composition decompose and thus furnish nutrients to growing plants.

6. It should be kept in mind that chemical nitrogen and other plant nutrients are usually much cheaper than are these constituents purchased in organic form.

Table 1

Average chemical composition of raw garbage of several cities determined at different times. (Dry basis)

	Total Nitrogen (N)	Phosphoric oxide (P_2O_5)	Total Potash (K_2O)
	percent	percent	percent
Chicago, Illinois, 1923	1.24	2.47	-
Canton, Ohio, 1945	2.08	1.64	0.63
Washington, D.C., 1950-53	2.70	-	-

Table 2

Average chemical composition of garbage tankage - heat-treated, fat removed. Data from various areas. (Dry basis)

	Total Nitrogen (N)	Phosphoric oxide (P_2O_5)	Total Potash (K_2O)
	percent	percent	percent
Philadelphia, Pa., 1923	2.60	3.21	0.4
Rochester, N. Y., 1926	2.81	2.50	-
California, 1931	2.70	1.85	0.79
Columbus, Ohio, 1932	2.91	2.33	0.93

Table 3

Composition of "humus" formed from garbage by different processes

Process and Time	Nitrogen (N)	Phosphoric oxide (P_2O_5)	Potash (K_2O)
	percent	percent	percent
Beccari Process Scarsdale, N.Y. 1926-27	2.57	2.14	0.95
Summary of data Beccari Process N. Y. 1930	2.80	3.07	1.17
Chemically fortified garbage compost - Calif. 1953	2.77	1.27	0.47
Pit fermentation of city garbage + Paunch manure, 10 weeks Haiti - 1953	0.95	1.18	1.16

Table 4

Prices of low-grade organic ammoniates and natural soil conditioners; retail quotations 100-lb. lots, Washington,D.C., 1953

Material	Approximate fertilizer grade	Price
		dollars
Cow manure	2 - 1 - 1	5.25
Sheep manure	2 - 1 - 1	5.25
Farm manure (poultry and sheep manure and peat)	2 - 1 - 1	5.00
Michigan peat	-	4.50
Cultivated peat (Humus) (moist, often about 50% water)	-	2.50

Table 5

Prices of high-grade organic ammoniates; retail quotations 100-lb. lots, Washington, D. C., 1953

Material	Fertilizer grade	Price	Price per pound of Nitrogen
		dollars	cents
Cottonseed meal	7 - 2.5 - 1.5	5.75	82
Milorganite	6 - 2.0 - 0	4.25	71
Tobacco waste	4 - 0.6 - 6	4.00	100*
Blood meal	**11- 0.6 - 0.6	10.50	95

* Potash content adds materially to value.
** Average nitrogen content of commercial blood meal is about 13 percent.

Table 6

Prices of chemical nitrogen carriers quoted by local stores, 100-lb. lots, Washington, D. C., 1953

Material	Nitrogen content	Price	Price per pound of Nitrogen
	percent	dollars	cents
Ammonium sulfate	20.0	4.75	23.8
Ammonium nitrate	33.5	6.75	20.3
Sodium nitrate	16	4.75	29.7
10-6-4 fertilizer	10	4.15	41.5*

*This figure is on the assumption that nitrogen alone is of value.

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